

SENSOR ELEMENT OR ACTUATOR ELEMENT HAVING AN  
ANTI-ADHESIVE SURFACE COATING

Field Of The Invention

The present invention relates to a sensor element or an actuator element, in particular for use in motor vehicles.

5     Background Information

6     Sensor or actuator elements are known in many variations. An  
example of one such sensor element is a hot-film air-mass  
meter. In the operation of sensors or actuators of this  
kind, the problem often occurs that under unfavorable  
10    conditions, such as in an operation in the intake manifold  
of a motor vehicle, these sensors or actuators become fouled  
(collect dirt) by the surface accumulation of dirty water,  
spray water, mineral oil, silicon oil, soot, salts,  
hydrocarbons, dust particles, etc. in that area of the  
15    sensor element that is actually sensitive, resulting in a  
short-term (for example in the case of spray water) or  
gradual deterioration in the sensor's signal.

20    Surface coatings used in the anti-adhesive of textiles to  
render them water- or oil-repellent, are known, for example,  
by the commercial name "Scotchgard" of the firm 3M Germany  
GmbH, Neuss. Fluorinated polymers and partially fluorinated  
polymers used to prevent the creepage of lubricating oils  
are also known as "epilamization agents". Also known are  
25    soil-repellent coatings having fluorine-containing silanes  
on glass and in the form of fluorine-containing polymers,  
which are precipitated out in plasma processes.

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## Summary Of The Invention

An advantage of the sensor- or actuator element in accordance with the present invention over the related art is that in an application under unfavorable conditions, for example in the intake manifold of motor vehicles, soiling or serious degradations in functioning caused by dirty water, spray water, mineral oil, silicon oil, soot, hydrocarbons, salts or dust particles on the sensor- or actuator element, can be substantially reduced, so that its service life and unrestricted performance reliability is ensured at all times, even under unfavorable conditions.

This is particularly true when the surface of, for example, sensor- or actuator components manufactured using silicon micromechanics, is made of dielectric layers, such as of silicon dioxide, silicon nitride, silicon, glass, ceramics, polymers or metals, which exhibit a high surface energy and, therefore, are rendered readily hydrophilic (easily wetted) by the foreign matter or impurities. In the case of the sensor- or actuator elements in accordance with the present invention, having an anti-adhesive and, in particular, organic or fluorine-containing surface coating as a protective layer, this kind of soiling or serious degradation of functioning is minimized by reducing the surface energy.

Furthermore, for example, the thickness of the anti-adhesive surface coating can be adjusted within a broad range of about 10 nm to 10  $\mu$ m, so that the sensor signal or actuator signal is not adversely affected by the surface coating. It is also very advantageous that the surface coating is temperature-stable up to at least 200°C and exhibits only a very low surface energy of 5 to 50 mN/m.

### Brief Description Of The Drawing

The Figure shows a block diagram of a hot-film air-mass meter having a coated sensor element.

### Detailed Description

In an exploded view, the Figure shows a generally known hot-film air-mass meter having a plug connection 13 with connection terminals, an evaluation circuit 15, an electronic space cover 14, a measuring channel cover 16, a support plate 11, a sensor element 10, and an air supply channel 12. This sensor is installed, for example, in an intake manifold of a motor vehicle, the sensor element being supplied via air-supply channel 12 with air and/or gases, which, at the same time, contain a multiplicity of unavoidable contaminants, such as dirty water, spray water, mineral oil, silicon oil, soot, hydrocarbons, salts or dust particles. Sensor element 10 is designed in the form of a chip of patterned silicon, and has a sensitive region located within air-supply channel 12. Sensor element 10 is provided with an anti-adhesive surface coating 20.

Anti-adhesive surface coating 20 is a thin, firmly adhering, temperature-stable, fluorine-containing layer, which, because of its low surface energy, prevents the substances and impurities mentioned above from adhering. Due to the small thickness of surface coating 20 of merely about 10 nm to about 10  $\mu\text{m}$ , the functioning of sensor element 10 or of an actuator element, even when working with functioning principles such as those of thermal anemometers, is, at the same time, not adversely affected in this context. Anti-adhesive surface coating 20 is, in particular, a fluorinated polymer, a fluorormocer, a fluorine-containing silane, a polymeric fluorocarbon resin, or a partially fluorinated

polymer.

INSAI A solution of a fluorinated polymer and/or of a fluoromocer  
in a preferably fluorine-containing solvent is applied using  
5 dipping methods, or sprayed, spin-coated, brushed,  
sprinkled, doctored, rolled, or vapor deposited on as  
surface coating 20 to sensor element 10. Depending on the  
application method used and the ratio of solvent to  
fluorinated polymer, the thickness of surface coating 20 is  
10 easily adjustable within the range of about 10 nm to 10  $\mu$ m.

Thus, after drawing off the solvent, an adherent polymer  
film is formed in a very simple manner on sensor element 10  
as a protective layer and anti-adhesive surface coating,  
15 whose thickness can be adjusted by varying the ratio of  
fluorinated polymer to solvent within the broad limits  
mentioned. Alternatively to coating the surface of sensor  
element 10 with fluorinated polymers or fluoromocers, the  
surface of sensor element 10 can also be coated with a  
20 fluorinated silane using dipping, spraying or spin-coating  
methods, as well as through plasma polymerization processes  
using fluorine-containing substances.

Particularly suited for sensor elements 10 according to the  
25 present invention are surface coatings 20, including the  
products FC 722, FC 732 or FC 725 of the firm 3M Germany  
GmbH, Neuss, or including the products F2/50 and FK60 of the  
firm Dr. Tilwich GmbH, 72160 Horb. Also suited, in  
particular, is a self-synthesized layer, which has added to  
30 it the product Foralkyl MAC 8 of the firm Elf Atochem, F-  
92300 Levallois, a polyfunctional methacrylate, a  
polymerization initiator and, if needed, a solvent; this  
solution is then used to coat sensor element 10.

The named surface coatings 20 do not cause any noticeable degradation of the hot-film air-mass meter's measuring signal. Suited, in particular, as sensor elements 10 for surface coating 20 are those of silicon, silicon dioxide, silicon nitride, of ceramic materials, glass, metals or polymers.

Since, in operation, the hot-film air-mass meter exhibits various temperature zones including temperatures of 150°C to 350°C, it is quite advantageous that a coating of fluorinated polymers decomposes, without leaving residues, at temperatures above 300°C, when the mentioned products of 3M and of Dr. Tilwich are used. Thus, in addition, an area that goes beyond the actual sensor element 10, such as the inner walls of the gas- or air-supply channel 12 and/or of the measuring channel cover, can also be coated with an anti-adhesive surface coating. In a first operation of the hot-air mass sensor, the applied anti-adhesive surface coating is burned away, without leaving residues, at those locations exposed to temperatures of above 300°C.

In the case of hot-air mass sensor 20, the inner walls of air-supply channel 12 are made, in particular, of a glass fiber-reinforced polybutylene-terephthalate injection molding compound and are, thus, likewise suited for an anti-adhesive surface coating having a fluorinated polymer base, further diminishing any degradation in the functioning of the sensor element according to the present invention caused, for example, by contaminants adhering to the inner walls.

Besides the hot-air mass sensor, various other sensors or actuators are suited for using an anti-adhesive surface

coating. For this, humidity, climatic, air quality, and temperature sensors come into consideration, in particular. In airbag sensors as well, an anti-adhesive surface coating can be applied to their inner side and/or to the resonant mass, to avoid "sticking". In addition, in the case of

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- actuators, for example, the baffle plate of an air-intake control or the rotor of a lighting dynamo is suited for an anti-adhesive surface coating.
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- The applied surface coating 20 of the material FC 722 is firmly adhering, in particular on silicon substrates as used for sensor element 10, and passes standard cross hatch (chipping) tests.

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